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EVAPORATION MEMORANDUM NO 31

DUPLICATE ALSO

ESTIMATING PENMAN FORMULA METEOROLOGICAL VARIABLES FOR HIGH GROUND LOCATIONS IN GREAT BRITAIN

by

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1. Introduction The Meteorological office model for agricultural and hydrological water balance (MAHWAB (X)), now under development, requires 7 - day and calendar month averages of air temperature, vapour pressure, saturation vapour pressure, daily duration of bright sunshine and wind speed at 2 metres at a regular grid of points 40 km apart in easting and northing. The altitudes associated with these points are the average altitudes of 40 x 40 km squares centred on the points. Some of these altitudes are considerable and the meteorological variables have to be estimated from data from, mostly low ground stations. This memorandum described some simple tests of the interpolation methods used in MAHWAB (X). The problem of estimating and interpolating 2m average wind speeds has already been examined by Wales - Smith (1973a, 1973b). The stations used in these are shown in Fig 1.

2. Monthly mean air temperature

Estimates for 3 high ground stations Huddersfield (232m), Glenmore lodge (341m) and Moor House (558m) are made from 3 sets of 4 low ground stations in Tables 1, 2 and 3 respectively.

The computer model uses inverse distance squared weighting and a temperature lapse rate of 0.6°C per 100 m Meteorological office (1975). In this test the heights of the low ground stations were each subtracted from the height of the high ground station and the results (expressed in 100s of m) were multiplied by 0.6°C and subtracted from the station mean temperatures; these adjusted temperatures were then averaged to give the values in columns A.

The values in columns B are averages of daily data at the high ground stations. The A-B values show the errors; these only exceeded 1°C four times at the highest station and then only reached 1.2°C. The only large A-B value in table 2 occurred when the eastern stations were particularly cloudy. Sets of 1 high and 4 low stations are few. It appears that the lapse rate of 0.6°C per 100m is adequate. Although a high ground station, Moor House is in a valley and could be expected to record unrepresentatively low temperatures.

3. Monthly mean vapour pressure

The procedure outlined in 2 was used with the formula obtained by Tunnell (1953) to produce the estimates in column A, Table 4. The A-B values are all satisfactorily small. As this is a published technique, only one example is given.

4. Monthly average saturation vapour pressure

Provided that daily s.v.p. values are averaged to give monthly means, the method used in (3) should be satisfactory.

FH 3

[1]

5. Monthly average daily duration of bright sunshine

In Tables 5 and 6 estimates are made for two high ground stations. The estimates in Table 3, column A are straight-forward averages of the 4 values, each month. Most estimates are too high but the A-B values are mostly small.

In Table 6 the above process is repeated and the resulting errors are shown as A-C. The values in column B have been obtained by dividing the tabulated sunshine duration values by the station long-period monthly averages, calculating the 4 - station averages of this quantity each month and finally multiplying this result by the appropriate long-period average for the high ground station.

These results are tabulated as B-C and are generally smaller than the corresponding A-C values showing that the introduction of long-period averages of sunshine duration increases the overall accuracy of interpolation.

April is the only month when the introduction of long-period averages made the estimate for the high-ground station significantly worse than simple interpolation. It will be noticed that the two eastern stations had far lower average values than the western stations.

August 1976

Meteorological Office (1975) Reduction of temperatures to sea level. Atlas Note No 2A - unpublished material, Meteorological Office Library.

Wales-Smith B G (1973a) Values of 7-day average, low-level wind speed for use in calculations of potential evapotranspiration by Penman's formula. Evaporation Memorandum No 20a - unpublished material, Meteorological Office Library.

Wales-Smith B G (1973b) Estimation of 7-day average values of wind speed at 2 metres (above ground) representative of 40 x 40 km squares of terrain. Evaporation Memorandum No 23a - unpublished material, Meteorological Office Library.

Tunnell G A (1953) Reduction of averages of vapour pressure to sea level. Met Mag 1953, 82, 103-112.

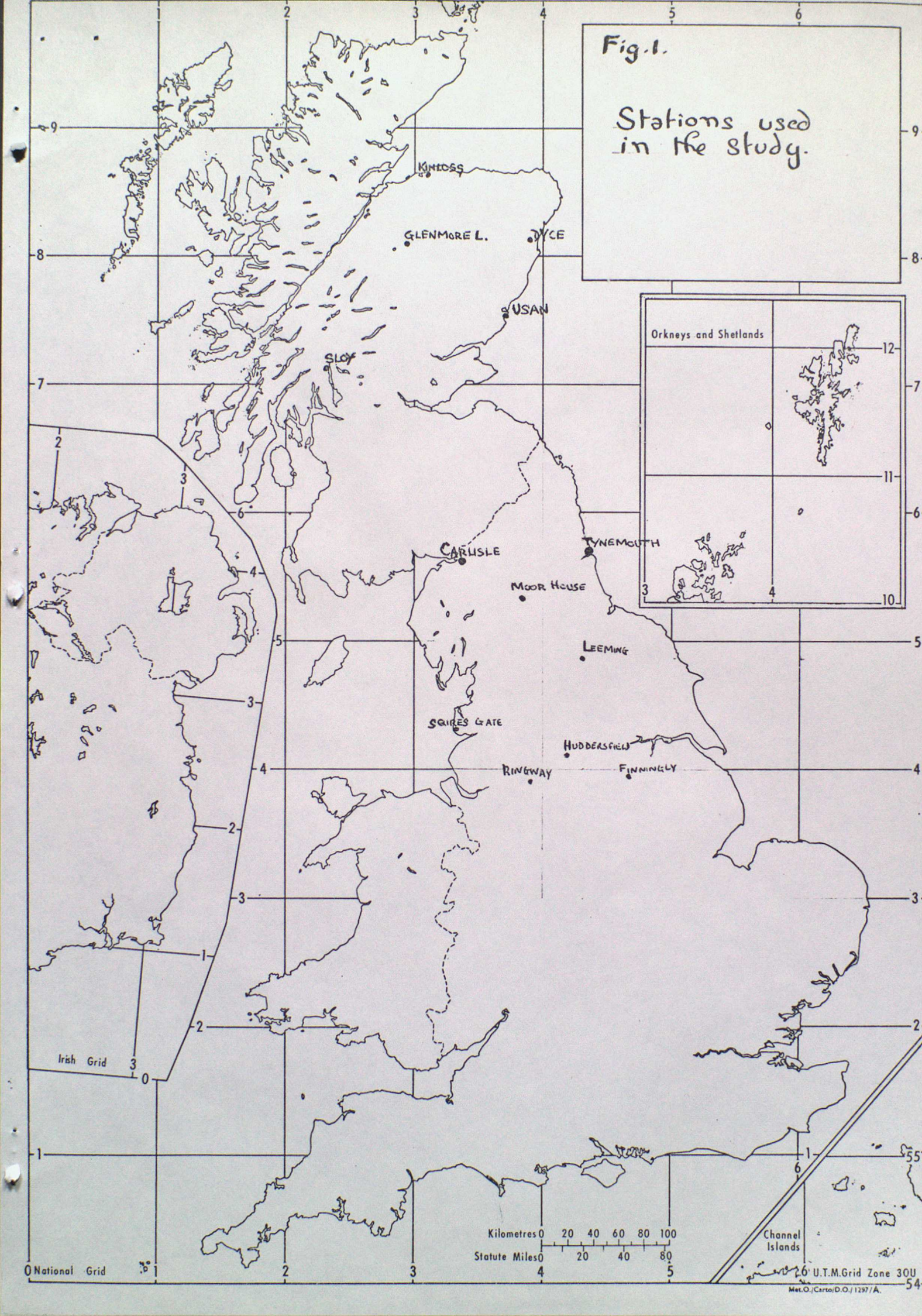
Fig.1.
Stations used in the study.
KINLOSS
GLENMORE L.
DYCE
USAN
SLOY
Orkneys and Shetlands
CARLISLE
TYNEMOUTH
MOOR HOUSE
LEEMING
SQUIRES GATE
HUDDERSFIELD
RINGWAY
FINNINGLY
Irish Grid
Kilometres 0 20 40 60 80 100
Statute Miles 0 20 40 80
Channel Islands
National Grid
U.T.M.Grid Zone 30U
Met.O./Carto/D.O./1297/A.

TABLE 1

1974 Monthly mean Temps °C.

	Squires Gate	Ringway	Finningley	Leeming	A Means of 4 Stations to left adjusted for alt.	B 1974 Monthly mean T Hundered'd	A−B T °C.
ALT m	10m	76m	10m	32m		232m	
JAN	6·0	6·1	5·5	5·4	4·6	4·9	−0·3
FEB	6·1	5·8	5·7	5·5	4·6	4·6	0
MAR	6·1	6·2	5·6	5·3	4·6	4·5	+0·1
APR	8·1	8·9	7·8	6·4	6·6	6·6	0
MAY	11·0	11·3	11·0	10·9	9·9	10·0	−0·1
JUNE	13·5	13·8	14·1	12·9	12·4	12·8	−0·4
JULY	14·9	14·7	15·3	14·7	13·7	13·9	−0·2
AUG	14·9	15·1	15·5	14·9	13·9	14·5	−0·6
SEPT	12·4	11·9	12·3	11·9	10·9	11·3	−0·4
OCT	8·4	7·7	8·1	7·6	6·8	6·7	+0·1
NOV	6·6	6·5	6·1	5·9	5·1	5·3	−0·2
DEC.	7·9	8·1	8·0	7·9	6·8	6·5	+0·3
					Mean Annual diff.		−0·14

TABLE 2

1974 Monthly Mean Temps °C.

	Kinloss	Dyce	Usan	Sley	A Means of 4 Stations to left adjusted for Alt	B Monthly mean Glenmoreldg.	A−B. T°C
ALT m	5m	58m	30m	12m		341m	
JAN	5·5	4·7	5·4	5·9	3·5	N/R.	N/R.
FEB	5·1	4·7	5·0	5·4	3·1	2·9	+0·2
MAR	5·1	4·3	4·6	4·8	2·8	3·4	−0·6
APR	6·9 *	6·5 *	6·1 *	8·0	5·0	6·3	−1·3 *
MAY	10·1	9·4	9·4	10·3	7·9	8·2	−0·3
JUNE	12·4	11·7	11·7	13·5	10·4	10·5	−0·1
JULY	13·5	13·0	13·3	13·2	11·3	11·2	+0·1
AUG	14·1	13·7	13·7	13·5	11·9	11·7	+0·2
SEPT	10·6	10·3	10·9	10·9	8·9	8·5	+0·4
OCT	7·6	7·2	7·7	8·1	5·7	4·9	+0·8
NOV.	5·7	5·5	6·1	6·1	3·9	3·5	+0·4
DEC.	6·1	5·6	5·7	7·2	4·3	4·3.	0
					Mean 11 month (Feb-Dec) A-B		−0·2

* daddy in cast.

TABLE 3

1974 Monthly mean Temps °C.

	Squires G	Leeming	Carlisle	Tynemouth	A Means of 4 Stations to left adjusted for alt.	B. 1974 Monthly mean of Most House.	A−B T°C.
ALT m	10m	32m	26m	27m		558m	
JAN	6·0	5·4	6·2	5·7	2·6	1·9	+0·7
FEB	6·1	5·5	5·7	5·7	2·5	1·5	+1·0
MAR	6·1	5·3	5·6	4·8	2·2	1·3	+0·9
APRIL	8·1	6·4	7·7	5·7	3·7	3·5	+0·2
MAY	11·0	10·9	10·9	9·8	7·4	6·5	+0·9
JUNE	13·5	12·9	12·9	12·0	9·6	8·5	+1·1
JULY	14·9	14·7	14·1	14·3	11·3	10·3	+1·0
AUG.	14·9	14·9.	14·3	14·7	11·5	10·5	+1·0
SEP	12·4	11·9	11·1	11·9	8·6	7·5	+1·1
OCT	8·4	7·6	7·1	7·9	4·5	3·3	+1·2
NOV	6·6	5·9	6·3	6·6	3·1	2·7	+0·4
DEC.	7·9	7·9	7·4	7·9	4·5	3·3	+1·2
					A−B. Mean Annual Diff		+0·9.

TABLE 4

1974 Monthly mean Vapour Pressures mb

	Squires Gate	Ringway	Finningley	Leeming	A. Means of 4 Stations to left adjusted for alt.	B. 1974 Monthly mean V.P. Hudders'd 232m.	A−B V.P. mb.
Alt m	10m	76m	10m	32m			
JAN	7.9	7.5	7.6	7.5	7.3	7.4	−0.1
FEB	8.0	7.7	7.7	7.5	7.3	7.4	−0.1
MAR	7.5	7.0	7.4	7.3	6.9	6.9	0.0
APR	8.2	7.5	7.9	7.8	7.5	7.6	−0.1
MAY	9.9	8.5	10.0	9.3	8.9	8.8	+0.1
JUNE	11.9	10.7	11.6	11.0	10.7	10.9	−0.2
JULY	13.8	12.9	13.0	12.7	12.5	12.7	−0.2
AUG.	14.3	13.1	13.9	13.5	13.0	13.1	−0.1
SEPT.	12.0	11.3	11.8	11.5	11.5	11.3	+0.2
OCT.	9.1	8.5	8.7	8.6	8.3	8.1	+0.2
NOV.	8.8	8.2	8.2	7.9	7.9	8.1	−0.2
DEC.	9.7	8.7	8.9	8.8	8.6	8.7	−0.1
					Mean Annual diff.		+0.03

TABLE 5

1974 Monthly mean Sunshine (hrs)

	Squires G	Ringway	Finningley	Leeming	A Means of 4 Stations to left.	B 1974 mean monthly S for Hudd'fd 232m	A−B. hrs.
Alt m	10m	76m	10m	32m			
JAN	1.59.	1.79	2.12	1.83	1.83	1.75	+0.08
FEB	2.06	1.76	2.29	2.24	2.09	1.64	+0.45
MAR	3.85	3.91	3.02	3.15	3.48	3.28	+0.20
APR	6.55	5.73	4.48	3.04	4.95	3.97	+0.98
MAY	6.58	5.99	6.64	6.44	6.41	5.85	+0.56
JUNE	8.17	6.38	5.64	5.49	6.42	5.55	+0.87
JULY	4.80	4.51	4.86	4.91	4.77	4.85	−0.08
AUG	5.16	5.56	5.95	5.18	5.46	5.40	+0.06
SEPT.	3.77	4.31	4.60	4.04	4.18	4.37	−0.19
OCT.	3.12	2.58	3.05	2.42	2.79	2.68	+0.11
NOV	1.61	1.26	1.87	1.98	1.68	1.74	−0.06
DEC.	1.20	1.02	1.92	2.11	1.56	1.16	+0.40
					Mean Annual Diff.		+0.28.

TABLE 6

1974 Monthly Mean Sunshine (Hours)

	Squires G	Leeming	Carlisle	Tynemouth	A. Means of 4 Stations to left	B Means of 4 Stns adjusted for longer averages	C 1974 mean monthly S. for Moor House 558m	Hours A−C	Hours B−C	
Alt m	10m	32m	26m	27m						
JAN	1.59.	1.83	1.59	1.79	1.70	1.12	0.45	+1.25	+0.67.	
FEB.	2.06	2.24	2.44	2.41	2.29	1.60	1.31.	+0.98	+0.29	
MAR	3.85	3.15	3.55	2.33	3.22	2.54	2.96	+0.26	−0.42	
APRIL	6.55	3.04*	6.83	2.56*	4.75	3.76	6.44	−1.69	−2.68.	*
MAY	6.58	6.44	6.45	6.16	6.41	5.73	6.36	+0.05	−0.63.	
JUNE	8.17	5.49	7.63	5.91	6.80	6.13	5.99	+0.81	+0.14	
JULY	4.80	4.91	4.35	5.81	4.97	3.98	3.80	+1.17.	+0.18.	* cloudy in east
AUG	5.16	5.18	4.96	5.93	5.31	4.53	4.18	+1.13.	+0.35.	
SEPT	3.77	4.04	3.50	4.30	3.90	3.09	2.98	+0.92	+0.11	
OCT	3.12	2.42	1.93	1.62	2.27	1.97	1.25	+1.02	+0.72	
NOV	1.61	1.98	1.95	2.46	2.00	1.53	0.82	+1.18	+0.71	
DEC.	1.20	2.11	1.13	2.04	1.62	1.28	0.47.	+1.15.	+0.81.	
			A−C and B−C Mean Annual Diff. Sun.					+0.69	+0.02	